

# Multiplicities in Pb-Pb central collisions at the LHC from running coupling evolution and RHIC data

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Predictions for the pseudorapidity density of charged particles produced in Pb-Pb central collisions at  $\sqrt{s_{NN}} = 5.5$  TeV presented in [1] are summarized. Primary gluon production in such collisions can be computed perturbatively in the framework of  $k_t$ -factorization. Under the additional assumption of local parton-hadron duality, the rapidity density of produced charged particles in nucleus-nucleus collisions at energy  $\sqrt{s}$  and impact parameter  $b$  is given by, [2]:

$$\frac{dN}{dy d^2b} = C \frac{4\pi N_c}{N_c^2 - 1} \int^{p_{kin}} \frac{d^2 p_t}{p_t^2} \int^{p_t} d^2 k_t \alpha_s(Q) \varphi\left(x_1, \frac{|k_t + p_t|}{2}\right) \varphi\left(x_2, \frac{|k_t - p_t|}{2}\right), \quad (1)$$

where  $p_t$  and  $y$  are the transverse momentum and rapidity of the produced particle,  $x_{1,2} = (p_t/\sqrt{s}) e^{\pm y}$  and  $Q = 0.5 \max\{|p_t \pm k_t|\}$ . The lack of impact parameter integration in this calculation and the gluon to charged hadron ratio are accounted for by the constant  $C$ , which sets the normalization. The nuclear unintegrated gluon distributions (u.g.d.),  $\varphi(x, k)$ , entering Eq. (1) are taken from numerical solutions of the Balitsky-Kovchegov evolution equation including running coupling corrections, [3]:

$$\frac{\partial N(Y, r)}{\partial Y} = \mathcal{R}[N(Y, r)] - \mathcal{S}[N(Y, r)] \quad (2)$$

Explicit expressions for the *running*,  $\mathcal{R}[N]$ , and *subtraction*,  $\mathcal{S}[N]$ , functionals in the r.h.s. of Eq. (2) can be found in [3]. The nuclear u.g.d. are given by the Fourier transform of the dipole scattering amplitude evolved according to Eq. (2),  $\varphi(Y, k) = \int \frac{d^2 r}{2\pi r^2} e^{i k \cdot r} \mathcal{N}(Y, r)$ , with  $Y = \ln(0.05/x) + \Delta Y_{ev}$ , where  $\Delta Y_{ev}$  is a free parameter. Large- $x$  effects have been included by replacing  $\varphi(x, k) \rightarrow \varphi(x, k)(1 - x)^4$ . The initial condition for the evolution is taken from the McLerran-Venugopalan model [4], which is believed to provide a good description of nuclear distribution functions at moderate energies:

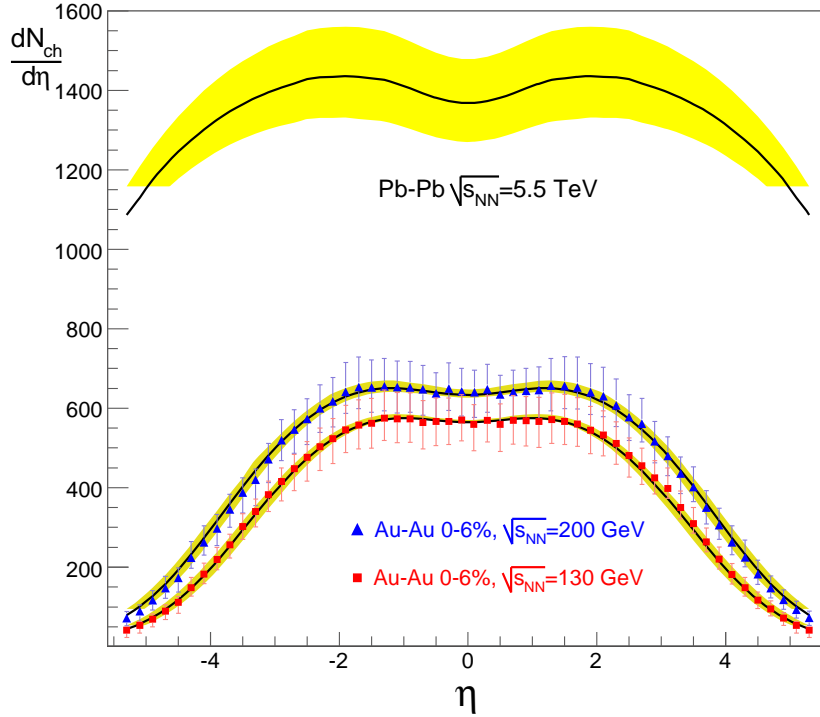
$$N^{MV}(Y = 0, r) = 1 - \exp\left\{-\frac{r^2 Q_0^2}{4} \ln\left(\frac{1}{r\Lambda} + e\right)\right\}, \quad (3)$$

where  $Q_0$  is the initial saturation scale and  $\Lambda = 0.2$  GeV. In order to compare Eq. (1) with experimental data it is necessary to correct the difference between rapidity,  $y$ , and the experimentally measured pseudorapidity,  $\eta$ . This is managed by introducing an effective

<sup>‡</sup> This research is sponsored in part by the U.S. Department of Energy under Grant No. DE-FG02-05ER41377.

hadron mass,  $m_{eff}$ . The variable transformation,  $y(\eta, p_t, m_{eff})$ , and its corresponding jacobian are given by Eqs.(25-26) in [2]. Corrections to the kinematics due to the hadron mass are also considered by replacing  $p_t \rightarrow m_t = (p_t^2 + m_{eff}^2)^{1/2}$  in the evaluation of  $x_{1,2}$ . This replacement affects the predictions for the LHC by less than a 5%, [1].

The results for the pseudorapidity density of charged particles in central Au-Au collisions at  $\sqrt{s_{NN}} = 130, 200$  and 5500 GeV are shown in Fig. 1. A remarkably good description of RHIC data is obtained with  $Q_0 = 0.75 \div 1.25$  GeV,  $\Delta Y_{ev} \lesssim 3$  and  $m_{eff} = 0.2 \div 0.3$  GeV. Assuming no difference between Au and Pb nuclei, the extrapolation of the fits to RHIC data yields the following band:  $\frac{dN_{ch}^{Pb-Pb}}{d\eta}(\sqrt{s_{NN}} = 5.5 \text{ TeV})|_{\eta=0} \approx 1290 \div 1480$  for central Pb-Pb collisions at the LHC. The central value of our predictions  $\frac{dN_{ch}^{Pb-Pb}}{d\eta}(\sqrt{s_{NN}} = 5.5 \text{ TeV})|_{\eta=0} \approx 1390$  corresponds to the best fits to RHIC data.



**Figure 1.** Multiplicity densities for Au-Au central collisions at RHIC (experimental data taken from [5]), and prediction for Pb-Pb central collisions at  $\sqrt{s_{NN}} = 5.5$  TeV. The best fits to data (solid lines) are obtained with  $Q_0 = 1$  GeV,  $\Delta Y_{ev} = 1$  and  $m_{eff} = 0.25$  GeV. The upper limit of the error bands correspond to  $\Delta Y_{ev} = 3$  and  $Q_0 = 0.75$  GeV, and the lower limit to  $\Delta Y_{ev} = 0.5$  and  $Q_0 = 1.25$  GeV, with  $m_{eff} = 0.25$  GeV in both cases.

## References

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